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RPPR Final Report
as of 11-Jan-2018

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Proposal Number: 68848RTREP **Agreement Number: W911NF-16-1-0511**
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STEM Degrees: 1 **STEM Participants:** 5

Major Goals: This final technical report details the status of the Autonomous Vehicle Systems (AVS) Research and Education Laboratory at the University of the Incarnate Word (UIW) located in San Antonio, TX. UIW is a Hispanic-Serving Institution. The AVS Lab was supported by a DoD HBCU/MI equipment grant from September 2016 to August 2017.

The long-term research goal for the PI is to investigate techniques for autonomous control, collaboration, and decision-making in unstructured, dynamic, and uncertain nonlinear environments for autonomous ground and air vehicle systems. To fulfill the research goal, the PI has initiated fundamental research in the areas of autonomous rotorcraft control and collaborative control of heterogeneous vehicles within the AVS Laboratory. The HBCU/MI equipment investment will be used to discover new and novel guidance, navigation, and control (GNC) techniques with application to unmanned ground vehicles (UGV) and unmanned air vehicles (UAV). The research objective of this proposal will be to develop new techniques in model predictive control (MPC), decentralized control of nonlinear complex systems, and then demonstrate these techniques' effectiveness using the equipment purchased by HBCU/MI funding in the areas of collaborative control, obstacle sense/avoid, and vehicle task allocation. The outcome of the research will be the application of these new techniques to the collaborative control of autonomous and semi-autonomous ground and air vehicles in uncertain and changing environments.

The HBCU/MI funded equipment will also allow the PI to support faculty guided undergraduate research in autonomous vehicle systems at UIW. The PI estimates that an additional four undergraduate students will participate in the proposed research each calendar year as part of their senior design project. A special focus will be made to recruit veterans into the AVS Laboratory as student researchers. Additionally, the AVS Lab will be used to support existing Department of Engineering, Physics, and Mathematics courses by providing equipment which can assist in applied learning of new concepts from lecture-based courses.

Accomplishments: Accomplished under Goals has been uploaded as a PDF document.

Training Opportunities: The following training opportunity was provided by this equipment grant:

Quanser Training to use equipment and software Jan 26 and 27, 2017 and August 3 and 4, 2017. The purpose of the training was to get the lab staff familiar with the equipment and software.

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Results Dissemination: The results of the research based on this equipment grant has been disseminated during the following events:

1) Interactive AVS Lab Demo demonstrating UAV collaborative control, 10th Annual Research Week at the University of the Incarnate Word, February 22, 2017.

2) miniGEMS STEAM and Programming Camp, June 5 to August 3, 2017, University of the Incarnate Word.

3) miniGEMS 2017 End of Summer Conference and Banquet, University of the Incarnate Word, August 4, 2017.

4) Various AVS Lab tours for Middle School and High School Robotics Clubs from the San Antonio, TX area.

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: PD/PI
Participant: Michael Frye
Person Months Worked: 12.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

CONFERENCE PAPERS:

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: 2017 ASEE Annual Conference & Exposition
Date Received: 03-Dec-2017 Conference Date: 25-Jun-2017 Date Published: 25-Jun-2017
Conference Location: Columbus, OH
Paper Title: miniGEMS 2016 – STEM Summer Camp for Middle School Girls
Authors: Sreerenjini Nair, Michael Frye
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: 2017 ASEE Gulf Southwest Section Conference
Date Received: 03-Dec-2017 Conference Date: 12-Mar-2017 Date Published: 12-Mar-2017
Conference Location: Richardson, TX
Paper Title: Multi Autonomous Vehicle Collaboration
Authors: Tomas Goldaracena, Miguel Reyes, Sreerenjini Nair, Michael Frye
Acknowledged Federal Support: **Y**

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Accomplished under Goals

The Autonomous Vehicle Systems (AVS) Research and Education Laboratory at UIW is part of the Department of Engineering in the School of Mathematics, Science, and Engineering. The long-term research goal for the AVS Laboratory is to investigate techniques for autonomous control, collaboration, and decision-making in unstructured, dynamic, and uncertain nonlinear environments for ground and air vehicles. Using the funds from the HBCU/MI equipment grant, the research from the lab will contribute to the understanding of the collaborative formation control of multi-agent autonomous systems in uncertain dynamic environments.

This research will have a direct impact on such DoD mission requirements as:
1) Autonomous tracking of a moving target by a formation of rotorcraft UAVs,
2) Collaborative control between rotorcraft and ground autonomous vehicles, and
3) Autonomous Aerial Refueling between multiple UAVs.

The AVS Lab has purchased the following equipment using HBCU/MI funds:
1) Quanser Unmanned Vehicle Systems Laboratory consisting of twelve programmable ground vehicles and eight programmable air vehicles, and ground workstations ($302,526)
2) Two Quanser Q-Brain Real-Time HIL Simulation Workstation ($13,490),
3) One Quanser 3 Degree of Freedom Quadcopter Hover Experiment ($22,285),
4) One Quanser 3 Degree of Freedom Helicopter Experiment ($23,650),
5) Quanser QuaRC Server License ($7,973),
6) Three Quanser STEM Outreach Systems and Physics Trainer ($15,180)
7) Three Quanser STEM Outreach Mechatronics Trainer ($15,840),
8) Qunser Training ($17,600), and
9) Ten Mathworks MATLAB and Simulink licenses ($29,040).

A Senior Design Project during the Spring 2017 semester investigated collaborative control using two Qball 2 UAVs at the AVS Lab. The results were disseminated at the Gulf Coast/Southwest ASEE Regional Conference. There are currently five UIW undergraduate engineering students participating in faculty led autonomous vehicle control research in the AVS Lab in the areas of collaborative control, machine learning, and UAV handling qualities.

The PI has been leading an effort in the AVS Lab investigating the interaction of ground-based robots and air vehicles to perform a collaborative logistical mission. The objective is the autonomous movement of cargo between remote locations; the cargo is flown autonomously by an air vehicle to a new point, lifted downward to a waiting ground robot, and then deployed by the robot to another location. As a first step to demonstrating this objective, the PI has been investigating a Machine Learning technique using Direct Inverse Control for the autonomous hover of a rotorcraft with externally slung loads. Additionally, the PI is investigating handling qualities for autonomous rotorcraft vehicle.